

CHAPTER 1 INTRODUCTION

1-1. Purpose. This manual provides technical criteria and guidance for civil works grouting applications. Information on procedures, materials, and equipment for use in planning and executing a grouting project is included, and types of problems that might be solved by grouting are discussed. Methods of grouting that have proven to be effective are described and various types of grout and their proportions are listed. The manual discusses grouts composed primarily of cementitious suspensions and additives although other types are mentioned.

1-2. Applicability. This manual is applicable to all field operating activities responsible for the design and construction of civil projects.

1-3. References. See Appendix A for list of references.

1-4. Changes. Users of this manual are encouraged to submit recommended changes or comments to improve it. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to ensure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded directly to HQUSACE (DAEN-ECE-G) WASH DC 20314.

1-5. General Considerations. Grouting in civil works activities is performed as: (a) an increment of permanent construction, (b) a postconstruction remedial treatment, and (c) an increment of expedient construction or repair. Examples of permanent construction are curtain grouting in the foundations for a dam and ground stabilization of foundation materials for large buildings. Examples of postconstruction remedial treatment include grouting voids under concrete structures and reducing leakage through a dam foundation or abutment. Grouting is used for both temporary and permanent treatments. It should be considered in combination with other appropriate types of treatment for best results. Other types of treatment may include excavation, compaction, concrete cutoff walls, slurry trenches, impervious blankets, drainage blankets and filter zones, relief wells, drilled drains, sheet pile cutoff, dental concrete, grouting and drainage tunnels and galleries, underpinning, and structural foundations. Purposes of expedient grouting include repair of roadways and cofferdams, and stability and groundwater control during construction.

1-6. Terminology.

a. Alkali-Aggregate Reaction. Chemical reaction in grout between alkalis (sodium and potassium) from portland cement or other sources and certain constituents of some aggregates; under certain conditions, deleterious expansion of the grout may result.

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b. Aquiclude. A body of relatively impermeable rock or soil that is capable of absorbing water slowly but functions as an upper or lower boundary of an aquifer and does not transmit groundwater rapidly enough to supply a well or spring.

c. Aquifer. A stratum or zone below the surface of the earth capable of producing water as from a well.

d. Aquitard. A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer; a leaky confining bed.

e. Area Grouting. Grouting of a shallow zone in a particular area that utilizes holes arranged in a pattern or grid. This type of grouting is sometimes referred to as blanket or consolidation grouting.

f. Bentonite. A clay composed principally of minerals of the montmorillonite group, characterized by high adsorption and very large volume change with wetting.

g. Blanket Grouting. As stated in e above.

h. Bursting Pressure (Grouting Equipment). The pressure at which equipment becomes inoperative.

i. Cement Factor. Quantity of cement contained in a unit volume of grout, expressed as weight or volume.

j. Cementitious Factor. Quantity of cement and cementitious materials contained in a unit volume of concrete, grout, or mortar, expressed as weight or volume.

k. Circuit Grouting. Grouting in a continuous manner with a grout circulating from the pump to the bottom of the zone to be treated and back to the pump.

l. Coefficient of Permeability (to Water). As stated in ad below.

m. Colloidal Grout. A grout that has an artificially induced cohesiveness, or the ability to retain the dispersed solid particles in suspension; i.e., a grout mixture that does not settle or bleed.

n. Consolidation Grouting. As stated in e above.

o. False Set. The rapid development of rigidity in a freshly mixed grout without the evolution of much heat. Such rigidity can be dispelled and plasticity can be regained by further mixing without the addition of water. Premature stiffening, hesitation set, early stiffening, and rubber set are other terms that refer to the same phenomenon.

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p. Final Set. A degree of stiffening of a grout mixture greater than initial set, generally stated as an empirical value indicating the time in hours and minutes that is required for cement paste to stiffen sufficiently to resist the penetration of a weighted test needle.

q. Flash Set. The rapid development of rigidity in a freshly mixed grout, usually with the evolution of considerable heat, and rigidity cannot be dispelled nor can plasticity be regained by further mixing without the addition of water; also referred to as quick set or grab set.

r. Free Water. Water that is free to move through a soil mass under the influence of gravity. Other terms are gravitational water, groundwater, and phreatic water.

s. Grout. A mixture of cementitious or noncementitious material, with or without aggregate, to which sufficient water or other fluid is added to produce a flowing consistency.

t. Grout Placement. The introduction of grout by gravity or pressure into voids; usually accomplished by grouting through pipes placed in the medium to be grouted or through drilled open holes penetrating the medium.

u. Grout Take. The volume of grout placed.

v. Heat of Hydration. Heat generated by chemical reactions of cementitious materials with water, such as that evolved during the setting and hardening of portland cement.

w. Hydrofracturing. The fracturing of an embankment or underground strata by pumping water under a pressure in excess of the tensile strength and minor principal stress.

x. Hydrostatic Head. The pressure produced by the height of a fluid above a given point.

y. Initial Set. A degree of stiffening of a grout mixture generally stated as an empirical value indicating the time in hours and minutes that is required for cement paste to stiffen sufficiently to resist the penetration of a weighted test needle.

z. Neat Cement Grout. A fluid mixture of cement and water or the hardened equivalent of such mixtures. Also called neat slurry.

aa. Packers. Expandable mechanical or pneumatic devices used to seal a hole or isolate portions of a hole.

ab. Perched Groundwater. Any groundwater separated by unsaturated rock from an underlying body of groundwater.

ac. Perched Water Table. The water table above an impermeable bed underlain by unsaturated rock or soil of sufficient permeability to allow movement of groundwater.

ad. Permeability (Laboratory) (to Water, Coefficient of). The rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unit hydraulic gradient and standard temperature conditions, usually 20°C.

ae. Pore Pressure. Stress transmitted through the pore water (water filling voids). Also called neutral stress and pore-water pressure.

af. Pressure Testing. Test performed to measure the rate at which water can be forced into a hole under a specific pressure.

ag. Pressure Washing. A process of washing between holes to remove mud and loose material from cracks and seams in the rock. In effect, it is a sluicing operation whereby water or air and water alternately are introduced under pressure into a hole and allowed to vent into adjacent cracks or escape from one or more adjacent holes.

ah. Primary Hole. The first series of holes to be drilled and grouted, usually at the maximum allowable spacing.

ai. Primary Permeability. The permeability of intact rock, rather than permeability due to fracturing.

aj. Primary Porosity. The porosity that develops during final stages of sedimentation or that was present within the sedimentary particles at the time of deposition.

ak. Refusal. The point during grout injection when little or no grout is accepted under the maximum allowable pressure or other specified conditions.

al. Secondary Hole. The second series of holes to be drilled and grouted, spaced midway between primary holes.

am. Section. A linear or areal subdivision of the grout treatment pattern without regard to the depth of treatment.

an. Seep. An area where water oozes from the earth.

ao. Series Grouting. Similar to stage grouting, except each successively deeper zone is grouted by means of a newly drilled hole, eliminating the need for washing grout out before drilling the hole deeper.

ap. Split Spacing. The procedure by which additional grout injection holes are located equidistant from previously grouted holes.

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aq. Stage. A stage is one complete operational cycle of drilling, cleaning, pressure washing, pressure testing, pressure grouting, and grout cleanout within a zone. Depths of stages in any hole depend on conditions encountered in drilling that dictate where drilling should stop and grouting commence.

ar. Stage Grouting. The grouting of progressively deeper zones in stages. Previously emplaced grout is removed prior to hardening, the hole is drilled to a deeper depth, and another stage is emplaced.

as. Stop Grouting. The grouting of a hole beginning at the lowest zone (bottom) after the hole is drilled to total depth. Packers are used to isolate the zone to be grouted.

at. Sulfate Attack. Harmful or deleterious reactions between sulfates in soil or groundwater and grout.

au. Tertiary Hole. The third series of holes to be drilled and grouted, spaced midway between previously grouted primary and secondary holes.

av. Thixotropy. The property of a material that enables it to stiffen in a short period, on standing, and to regain its initial viscosity by mechanical agitation; the process is reversible.

aw. Time of Setting.

(1) Final setting time. The time required for a freshly mixed grout to achieve final set (harden).

(2) Initial setting time. The time required for a freshly mixed grout to achieve initial set.

ax. Unit Weight. The weight of freshly mixed grout per unit volume, often expressed as pounds per cubic foot.

ay. Viscosity. Friction within a liquid due to mutual adherence of its particles; i.e., the "thickness" of a mixture.

az. Void Ratio. The ratio of the volume of void space to the volume of solid particles in a given soil mass.

ba. Washing. The physical act of cleaning a hole by circulating either water, water and air, acid washes, or water and dissolved chemical substances, through drill rods or tremie pipe in an open hole.

bb. Water/Cement Ratio (Cement Only). The ratio of the amount of water to the amount of cement in a grout mixture, expressed by weight or volume.

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bc. Water/Cement Ratio (Total Cementitious Materials). The ratio of the amount of water to the amount of total cementitious materials in a grout mixture, expressed by weight or volume.

bd. Water Table. The upper surface of a saturation zone, except where that surface is formed by an impermeable body.

be. Working Pressure. The pressure adjudged best for any particular set of conditions encountered during grouting. Factors influencing the determination are size of voids to be filled, depth of zone to be grouted, lithology of area to be grouted, grout viscosity, and resistance of the formation to fracture or uplift.

bf. Zone. A predetermined subdivision of the overall depth of grout treatment. A single zone may make up the full depth of treatment, or the depth of treatment may be divided into several zones.